K2 Observations of Pulsating Subdwarf B Stars for Field 1

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During its primary mission, Kepler detected 19 pulsating subdwarf B (sdB) stars, none of which were known to pulsate previously. What we discovered from those observations (15+ papers) has transformed our knowledge of these important compact objects:

i) We learned that they have asymptotic g-modes, which is useful for mode identifications and contrary to structure models, indicating their interior structure is less stratified than predicted.

ii) We detected frequency multiplets, which also identify modes, provide the rotation period of the star, and the inclination of the pulsation geometry.

iii) Discovered rotation periods have been long (25-100 days), even for stars in close binaries, which was a surprising result and explains why frequency multiplets are rarely observed from the ground.

iv) Similar period spacings were found in red clump stars, indicating that sdB stars *do* represent the cores of most horizontal branch stars, but without the complexities of thick H envelopes.

v) Two stars which differ substantially from the other 17 in unique ways: One is a stochastic pulsator (Ostensen et al. 2014, submitted) and one clearly shows a mode trapping sequence (Ostensen et al. 2014, in press). We have no idea what fraction of sdB pulsators show these properties.

The period spacings and tens of identified modes will allow tight constraints on structure models, on a per-star basis. Kepler observations now over-constrain models, so these data have great potential.

So what can we expect to learn from K2? Firstly, each Kepler-observed sdB star for which multi-year observations have been examined, has shown some slightly different or unique features. It is suspected that these are caused by differing age, composition, and/or core/envelope mass, though these are currently unknown. This indicates that we do not have enough stars to fill in the differences. Yes, what we have is useful, but more will certainly aid in filling in the evolutionary/mass details of He-burning cores. Secondly, there has been a longstanding observation that hotter horizontal -branch stars rotate faster than cool ones (e.g. Peterson, Rood, & Crocker 1995, ApJ, 453). We do *not* find this result for sdB stars, which are extremely hot horizontal-branch stars. One of the most exciting discoveries from K1 is that sdB stars, even in 0.5 day binaries are *slowly* rotating (e.g. Pablo et al. 2012, MNRAS 422). Using stars in and out of binaries, rotation will be extremely useful for learning how angular momentum has coupled to the envelope (e.g. Kawaler & Hostler 2005, ApJ, 621) *and* how it has been affected by the mass loss which produced the thin envelope (e.g. Han et al. 2003, MNRAS, 341, 669). Indeed, to understand sdB stars properly we must do good asteroseismology for at least four groups; short-period sdB binaries with white-dwarf companions (formed by common -envelope ejection or CEE) , short-period binaries with M-dwarf companions (also CEE), long-period binaries with G/F-type companions (stable Roche lobe overflow) and putatively single sdB stars (white-dwarf mergers or CEE from a *planetary* companion). The current sample of 19 Kepler g-mode pulsators barely covers the parameter space but demonstrates that Kepler data for even a single quarter can provide outstanding results.

We are proposing 4 sdB stars in Field 01. These were GALEX-selected, and effort has been made to obtain spectroscopic and photometric follow-up observations since the K2 announcement to ensure they are in the proper range for pulsations to be excited. None of them are currently known to pulsate, but our detection rate with Kepler is roughly 80%, so there is a high probability for success. EPIC #s 201904053 and 201206621, in particular, fall in the middle of the known g-mode pulsation region. EPIC #s 201531672 and 201203416 are on the hot side, which would be extremely useful for mapping differences across temperature. All of these stars are sufficiently bright that ~80 days of SC data should yield detection limits of a few tens of ppm (depending on brightness and crowding/pointing precision). All 19 of the K1 sdB pulsators would be detected from a K2 data set. Our preference is strongly for SC data for these targets, as most g-mode pulsators have pulsations past the LC Nyquist and many have p-modes too, with periods of a few minutes. Reed et al. (2012, MNRAS, 427) show an example of how SC data provide better results than LC. However, LC data would still be useful for statistics on frequency ranges and mode density.